

PATENT

SPECIFICATION

Inventors: **SHERI L. MCGUIRE**
 THOMAS E. TAYLOR

Title: **NEEDLEPUNCH FLAME-RETARDANT NONWOVENS**

This application is a Continuation-In-Part of my co-pending U. S. Patent Application Serial No. 10/298,990 filed November 18, 2002.

BACKGROUND OF THE INVENTION

1) FIELD OF THE INVENTION

The present invention concerns a flame-retardant (FR) nonwoven fabric that can be employed in many applications, particularly in household goods such as a fabric FR layer for comforters, pillows, or furniture; backing for curtains and rugs; and especially for mattress fabrics. The nonwoven fabric comprises at least one of FR rayon fiber, FR acrylic fiber, FR melamine fiber, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber; and optionally non-bonding, non-FR synthetic fiber and/or natural fiber, all of which are mechanically bonded together through a needlepunch process. Nonwoven fabric prepared from these components, possessing a batt weight of greater than about 2.25oz./sq. yd. is capable of passing stringent flame-resistant tests.

2) PRIOR ART

Flame-retardant or flame-resistant (FR) materials are well known to those skilled in the textile art. Such materials can be woven or nonwoven, knitted, or laminates with

other materials such that they pass various textile flame resistant or flame retardant tests such as California TB 117 & TB 133 for upholstery; NFPA 701 for curtains and drapes; and California Test Bulletin 603 dated November 4, 2003 concerning a flammability test procedure for residential mattress/box spring sets.

Generally, the California Technical Bulletin 603 test for mattresses states that the mattress must not release too great a quantity of energy for a given exposure to a flame, based on certain conditions such as the position of the flame, the temperature of the flame, the source of fuel being used, etc. Furthermore, 30 minutes after the flame source has been initiated the test is terminated and certain conditions must be met, as more fully set forth herein.

Various FR fibers are well known to those skilled in the art. FR fibers based on polyester, rayon, melamine, nylon, acrylic, and polyolefin fibers such as polyethylene, or polypropylene fibers, are known and commercially available.

U. S. Patent 6,214,058 issued to Kent et al. on April 10, 2001 describes fabrics made from melamine fibers that may or may not be flame resistant fabrics. This reference describes a process for dyeing melamine fabrics including blends of melamine and natural fibers (such as wool or cotton) or other synthetic fibers such as rayon or polyester. As a passing comment it mentions that the melamine fiber may be FR.

U. S. Patent 6,297,178 issued to Berbner et al. on October 2, 2001 discloses flameproof fabrics based on FR melamine fibers and FR rayon fibers. The melamine and rayon fibers are made FR by coating the fiber with aluminum.

PCT application WO 03/023108 filed September 11, 2002 in the name of Mater and Handermann discloses a highloft FR material composed of FR rayon or FR melamine that are inherently FR. Additionally the application also discloses and requires the use of modacrylic fibers. These materials have no coating thereon.

In spite of the above-mentioned patents and numerous other nonwoven FR fabrics, there is still a need in the industry to create inexpensive nonwoven FR articles that pass the stringent guidelines for the California Technical Bulletin 603 testing as well as other tests for upholstery, curtains and drapes. Moreover, there is a need in the industry to produce such a nonwoven article from materials that are relatively inexpensive, and have light batt weights.

The present invention relates to nonwoven fabric that is capable of passing the California Technical Bulletin 603 test when the nonwoven article is employed in a mattress, as well as other tests employed for other household goods like bed clothing and furniture.

The nonwoven fabric/article of the present invention may be produced from a combination of FR synthetic fibers and/or from all natural fibers. In each case, the nonwoven article is created by mechanically interlocking the fibers of a web. The mechanical interlocking is achieved through a needlepunch operation. Additionally, the nonwoven article has at least one of FR rayon fibers, FR acrylic fibers, FR melamine fibers, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber.

In the broadest sense, the present invention relates to a nonwoven article produced from at least one of FR rayon fibers, FR acrylic fibers, FR melamine fibers, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber; and optionally non binding, non FR synthetic fiber and/or natural fibers.

In the broadest sense, the present invention also comprises a nonwoven article produced from at least 2 FR fibers of the group of FR rayon fibers, FR acrylic fibers, FR melamine fibers, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber, and optionally a non-binding synthetic fiber.

In the broadest sense, the present invention also concerns a nonwoven article produced from at least 2 FR materials selected from the class of FR rayon fibers, FR acrylic fibers, FR melamine fibers, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber, and a non-binding synthetic fiber.

In the broadest sense, the present invention also concerns a nonwoven article produced from synthetic fiber, natural fibers, and FR resin coated fiber.

The nonwoven article of the present invention is produced from materials generally known to those skilled in the art, however, before the present invention those materials have not been assembled into a nonwoven article like that of the present invention.

Suitable FR fibers are those that can pass the various tests set forth below. FR fibers having too little flame resistance are not suitable for the present invention. Sufficient amounts of FR fibers must be present if the nonwoven article is to pass the California Test Bulletin 129 and 603 tests.

The FR fibers employed in the nonwoven articles of the present invention may be an inherent flame resistant fiber or an FR fiber (natural or synthetic fibers) that are coated with an FR resin. An inherently flame resistant fiber may be one whose polymeric structure incorporates an FR component such as phosphorus or phosphorus compounds, an amine, modified aluminosilicate, or halogen based compounds. An especially preferred halogen based compound is a thermoplastic polyvinyl halide composition. Thermoplastic polyvinyl halide compositions, when exposed to a flame, generate oxygen depleting gases that help to extinguish the flame. Thus it is inherently flame resistant. Modacrylic fiber is a generic name for a synthetic manufactured copolymer fiber composed of between about 35 wt. % and 85 wt. % of acrylonitrile units ($-\text{CH}_2\text{CH}(\text{CN})-$), with the remainder being thermoplastic polyvinyl halide, such as vinyl chloride or vinylidene chloride monomers. Suitable modacrylic fibers are sold under the trade name of Modacrylic™ distributed by Mitsui Textile Corporation, Protex sold by Kaneka, or

SEF Plus by Solutia, Inc. These modacrylic fibers are copolymers of acrylonitrile and vinyl chloride or vinylidene chloride. Other inherently flame resistant fibers are: a) rayon with aluminosilicate modified with silica and sold by Sateri Oy in Finland under the trademark Visil® fiber; b) a melamine fiber sold under the trademark Basofil® fiber by McKinnon-Land-Moran LLC.; and c) polyester with phosphalane (organo phosphorus compound) such as that sold under the trademark Trevira CS® fiber or Avora® Plus fiber by KoSa. These inherent flame resistant fibers are not coated, but have an FR component incorporated within the synthetic material (within its structural chemistry). Generally inherent FR fiber does not melt or shrink away from the flame, but forms a char that helps control the burn and shield the materials surrounded by fabric.

The natural or synthetic fibers coated with an FR resin contain one or more of the same type components mentioned above, namely phosphorus, phosphorus compound(s), red phosphorus, esters of phosphorus, and phosphorus complexes; amine compounds, boric acid, bromide, urea-formaldehyde compound(s), phosphate-urea compound(s), ammonium sulphate, or halogen based compounds. The typical FR resin is clear or translucent latex and is applied by spraying. Other non-clear FR resins are also known and are employed where color is not important. A suitable commercially available FR resin is sold under the trade name Guardex FR, or FFR which is produced by Glotex Chemicals in Spartanburg, South Carolina. While there are several different varieties of Guardex and Glotex FR resins, those skilled in the art can pick and choose among them to find that which is most compatible, taking into account such things as cost, appearance, smell, and the effect it may have on other fibers in the nonwoven batt (i.e., does it make the other fibers rough, or have a soft hand, or discolor the other fibers, etc.). FR resin may be applied to specific fibers in a range from about 6 to 25 weight % of the weight of the specific fibers or the nonwoven article. For example, the FR resin could be applied to natural or synthetic fibers before they are dry laid/air laid onto a conveyor belt. It is also within the scope of the present invention to purchase the fiber already coated with the desired FR resin coating, and merely blend them into the nonwoven fabric. The FR resin employed is a type that has no binding characteristics. Non-resin coatings like

metallic coating are not suitable for the present invention, because they tend to flake-off after continuous use of the product.

While the above FR product (Guardex) is a liquid product applied as a spray, other FR resin in solid form may be applied as a hot melt product to the fibers, or as a solid powder which is then melted into the fibers.

The FR fibers come in different deniers from approximately 1.5 to about 15 dpf (denier per filament).

Suitable non-FR synthetic fibers can be polyester such as polyethylene terephthalate (PET), rayon, nylon, polyolefin such as polyethylene fibers, acrylic, melamine and combinations of these. Other synthetic fibers not mentioned may also be employed. When non-FR synthetic fibers are employed, they give the batt certain characteristics like loft, resilience (springiness), tensile strength, and thermal retention, useful for many different applications. Preferred are PET and rayon fibers.

Natural fibers may also be employed in the nonwoven batts of the present invention. Natural fibers such as flax, kenaf, hemp, cotton and wool may be employed, depending on the properties desired. Preferred is cotton.

Because the synthetic fibers and natural fibers are non-binding and are not flame resistant, such fibers can be used to dial-in desired characteristics and cost. As such it is also within the scope of the present invention to employ a mixture of synthetic and natural fibers.

The nonwoven batt may be constructed as follows. The various combinations of fibers that can be employed in the present invention may be weighed and then dry laid/air laid onto a moving conveyor belt, for example. The size or thickness of a nonwoven batt is generally measured in terms of ounces per square yard. The speed of the conveyor belt, for example, can determine or provide the desired batt weight. If a thick batt is

required, the conveyor belt moves slower than for a thin batt. The weight % of the total fibers in the batt is 100%. This doesn't include the weight of the FR resin since it is not in fiber form.

Suitable nonwoven fabrics of the present invention have a batt weight greater than about 2.25 oz./sq. yd. Preferably the batt weight ranges from 2.25 oz./sq. yd. to 20 oz./sq. yd, with the most preferred product being 3.5 oz./sq. yd. Using a batt weight greater than about 20 oz./sq. yd. offers no significant improvement in performance and is more costly. If desired any rearrangement of the fibers such as by carding occurs next. Then the conveyor belt moves to an area where any spray-on material is added to the nonwoven batt, for example, the FR resin sprayed onto the nonwoven batt as a latex while the batt is still positioned on the conveyor belt. If the conveyor belt is foraminous, the excessive latex FR resin drips through the belt and may be collected for reuse later. After spraying the FR resin latex, it is transported to a dryer or oven. Once all the dried sprayed-on materials have been applied, if any, the conveyor belt can then move the nonwoven dry laid batt to the needlepunch loom where the fibers of the batt are mechanically oriented and interlocked.

In another embodiment of the invention, individual fibers are treated with the FR resin prior to the laying of the fibers (dry laid) onto the conveyor belt. Suitable fibers that have been pretreated with FR resins are commercially available. Utilizing the pretreated fibers eliminates the necessity to spray on the FR resin, and the drying time associated therewith.

The batt passes into the needlepunch loom between the bed plate on the bottom and the stripper plate on the top. Needles that are attached to one or more needle boards correspond to holes that are in one or both of the bed plate and the stripper plate. The needle board(s) moves up and down allowing the needles to pass through the plates, into and out of the batt. As the needles penetrate into the batt, barbs on the blade of the needle hook onto fibers in the batt, pulling the fibers the depth of the penetration. As the needle then moves out of the batt, the barbs release the hooked/pulled fibers, leaving the

hooked/pulled fibers reoriented from a horizontal to a predominantly vertical position. This causes the fibers of the batt to become entangled, which creates the nonwoven fabric.

Generally, the more penetrations of the needles into a given area of the batt, i.e., an increase in the puncture density, the more dense and strong the web will become. This increase in web density can be achieved by increasing the density of the needles in the needle board, decreasing the rate of material feed, increasing the frequency of punching, or similarly changing other operational production parameters that would be obvious to one skilled in the art. The depth of penetration by the needles into the batt has a similar effect on the strength and density of the nonwoven fabric. With an increase in the depth of penetration, a greater number of barbs along the needle blade are employed, resulting in greater entanglement of the fibers within the batt, and therefore a stronger, denser web. The now entangled and interlocked batt is pulled through the loom with the aid of draw rolls and wound onto tubes. The nonwoven batt may be used as an outer wrap in conjunction with other stuffing materials. In this arrangement, the nonwoven web provides a flame resistant barrier around a typically non-flame resistant filling.

Currently there are test standards in effect for mattresses for home (residential) use known as California Technical Bulletin 603 with an implementation date of 2005. The purpose of this test is to provide a means of determining the burning behavior of mattress/foundation sets intended for residential use by measuring specific fire test responses when the test specimen, a mattress plus foundation, is subjected to a specified flaming ignition source under well-ventilated conditions.

GENERAL PROCEDURES

Various fiber components, some FR fibers and some synthetic fibers (primarily employed for increasing physical properties of the nonwoven batt) are set forth in the

various examples having a range of dpf between 1.5 - 15 as mentioned previously. Also, the weight of the fiber batt as well as a pilot burn test designed to mimic the California TB 603 testing protocol is set forth in the examples.

Additionally, some sample where tested under the California TB 603 test that requires the test specimen to be conditioned for 24 hours at above 54°F and below 70% relative humidity. It was then placed on a steel frame, on a load cell platform along the far side of the test room. A pair of propane burners was placed on the top panel and border as specified in the test protocol. The computer data acquisition system was started, and the burners were ignited and allowed to burn for 70 seconds (top) and 50 seconds (border). The test was allowed to proceed until either all combustion ceased, or 30 mins passes.

The most important fire test response characteristic measured in this test is the rate of heat release, which quantifies the energy generated by the fire. The specimen does not meet the test requirements if any of the following criteria are exceeded:

1. Maximum rate of heat release of 200 KW.
2. Total heat release of 25 MJ in the first 10 minutes.

EXAMPLES

Various combinations of FR fibers with other synthetic or natural fibers such as rayon, PET, flax and kenaf were produced. The various fibers were dry laid onto a moving conveyor belt as is known in the art. For Samples 1 - 5 and 11, where an FR resin was employed via saturation method, it was applied to individual fibers before they were laid onto the moving conveyor. The nonwoven fiber batt was transported via the conveyor belt to a card, then to a needlepunch loom where the individual fibers were mechanically entangled through the needling process to create the interlocked web.

These various nonwoven batts, at various weights, were then subjected to Western Nonwovens bench scale test. In the test the nonwoven fabric was wrapped once around the foam. A flame was applied directly to the nonwoven fabric for at least 600 seconds and the structural integrity was noted. All of the test samples maintained their structural integrity for at least the time indicated, and the flame did not reach the foam. The burn time is listed in seconds. The batt weight is listed in ounces per square yard.

In all samples where FR resin was employed (Samples 1 - 5, 11 and 12) GUARDEX FR resin was used. All Samples containing an FR rayon employed Visil® fiber as the FR rayon. The FR resin is based on the total weight of the fibers employed to make up the nonwoven batt, except Sample 11 where the FR resin was employed only on the rayon. In all samples, the nonwoven web was interlocked together using needlepunch techniques generally known in the art.

When FR components, including but not limited to FR rayon fiber, FR acrylic fiber, FR melamine fiber, FR polyester fiber, FR polyolefin fiber, or FR resin coated fiber, are employed in the nonwoven batt they should be present in a concentration from about 25 to about 90 weight %, and preferably from about 30 to about 85 weight %. Synthetic fibers, which can be polyester and in particular PET fibers, are present from about 10 to about 70 weight %, and preferably from about 15 to about 65 weight % when employed in the nonwoven batt.

In all Samples except 12, the nonwoven batt was constructed of PET and varying amounts of FR rayon, FR acrylic, and/or FR melamine. Each batt had a final weight of about 9.0 oz/yd². The batt was then wrapped around a piece of foam and subjected to a burn test as described above. Each batt was subjected to a burn time test of over 600 seconds. All of the test samples maintained their structural integrity for at least the time indicated, and the flame did not reach the foam.

Sample 9 was also made up into twin-size mattresses and submitted for California TB 603 testing. Sample 9 was tested at 9oz/yd² in a 1-sided, pillow top design; and also a 2 sided bed. Sample 9 successfully passed in both bed constructions.

Sample 12 contains natural fibers - flax and kenaf, and synthetic PET fiber. These fibers are made into a batt and all the fibers were coated with an FR resin. The amount of FR resin was 20 wt. % based on the weight of the natural and synthetic fibers. The FR resin spray coated on the fibers was GuardEx FFR from Glo-Tex. This batt was not tested.

Lastly, the nonwoven batt from Sample 13 was constructed from Visil® fiber and PET fiber. It was constructed into a twin size mattress in compliance with and as described in California Technical Bulletin 603. The batt's weight was 5.85oz/yd². The mattress was then subjected to the full Flammability Test Procedure for Residential Mattresses that is described in TB 603. As indicated, a flame was applied directly to the mattress's upper surface (70 seconds) and side surface (50 seconds) utilizing a pair of propane burners. The structural integrity of the mattress was noted thereafter for a period of 30 minutes. The flame did not penetrate the nonwoven ticking employed around the mattress. There was no appreciable heat release during the burn time testing. Sample 13 was tested at 5.85 oz./sq.yd. in a two-sided twin bed construction. The mattress successfully passed TB 603.

All key data and results, if any, are summarized in Table 1.

TABLE 1

Sample	FR Rayon	FR Acrylic	FR Melamine	Rayon	PET	FR PET	Flax	Kenaf	FR Resin	Batt Weight	Burn Time Test
1				50	50				20%		
2		30	25	30	15				20%		
3	30	30	25		15				20%		
4	30	30			40				20%		
5				80	20				20%		
6		40	40		20						
7	40				60					9.0 oz/yd ²	600+ sec.
8	30	30	25		15					9.0 oz/yd ²	600+ sec.
9	40	30			30					9.0 oz/yd ²	600+ sec. & TB603
10	40				30	30				9.0 and 11.25 oz/yd ²	600+ sec. & TB603
11				40	30	30			15% on rayon only	9.0 oz/yd ²	
12					50		25	25	20%		
13	55				45					5.85 and 9.0 oz/yd ²	600+ sec. & TB603

Note: Samples 1-6, 11 and 12 have not been tested.

Thus, it is apparent that there has been provided, in accordance with the invention, a nonwoven fabric that fully satisfies the objects, aims, and advantages set forth above. While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. According, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the invention.